Armed Forces College of Medicine

AFCM

Lecture 2

Sensory receptors

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INTENDED LEARNING OBJECTIVES (ILO)

he end of this lecture you must be able to:

1. Define sensory receptors.
2. Classify receptors according to the type of the stimulus.
3. Name the properties of sensory receptors, and explain specificity.
4. Describe receptor potential .
5. Describe the relation between the sensation & the frequency of discharge in a sensory nerve & the intensity of stimulation.
6. Explain receptor adaptation.

Sensory receptors are specialized structures that act as both:

Detectors: **They detect changes in the external or internal environment of the body.**

Transducers**: They convert the energy of the change they have detected into electrical impulses.**

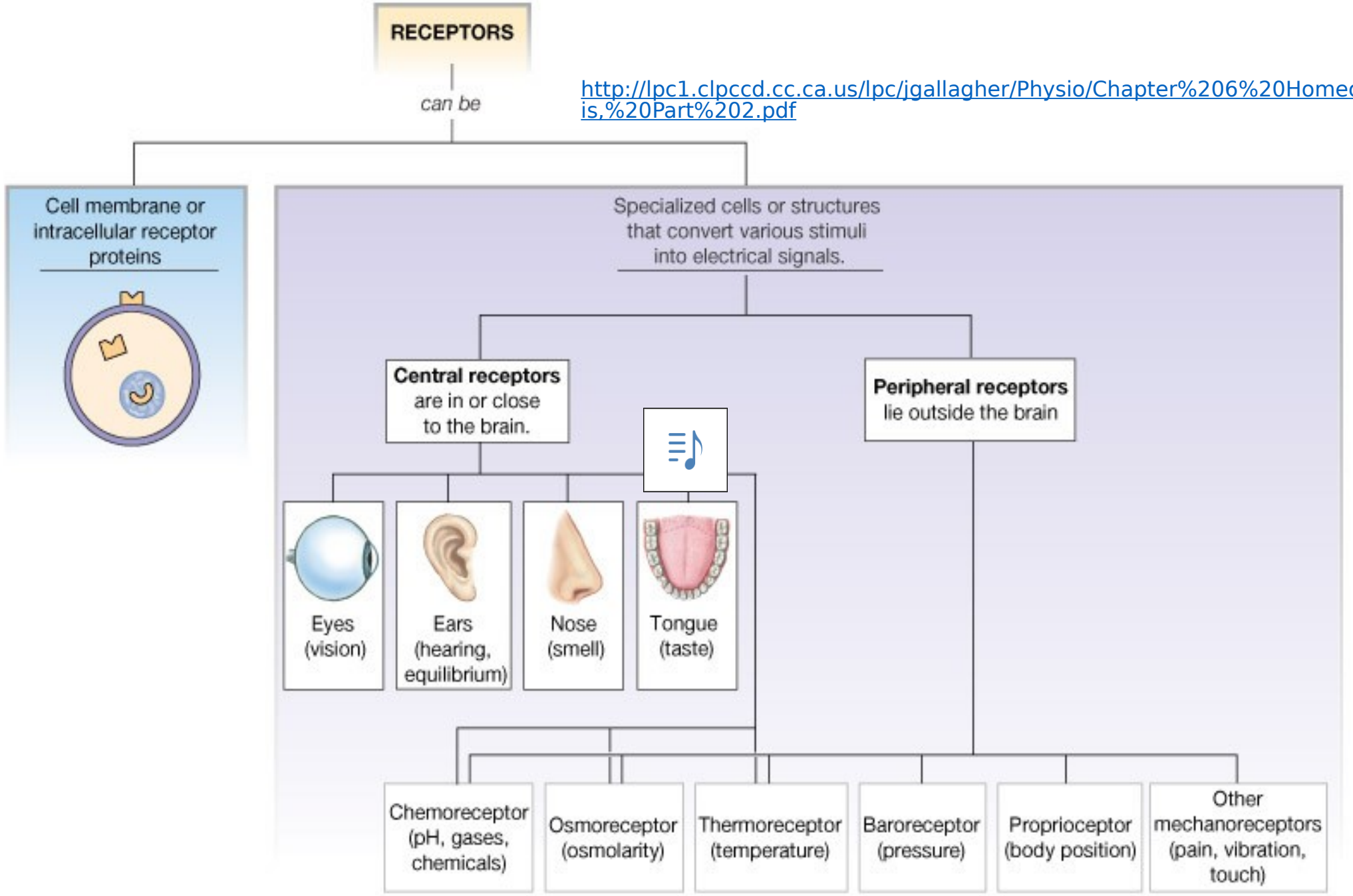
Location & Types of receptors

They are located at the peripheral ends of sensory neurons (specialized cell), mainly in receptors that are concerned with vision, hearing, equilibrium & taste.

Or, they may be part of the neuron itself (examples cutaneous receptors & Pacinian corpusles (touch receptor).

They are excitable structures, since they respond to stimuli by generating an action potential .

https://www.austincc.edu/apreview/PhysText/PNSafferent01.html



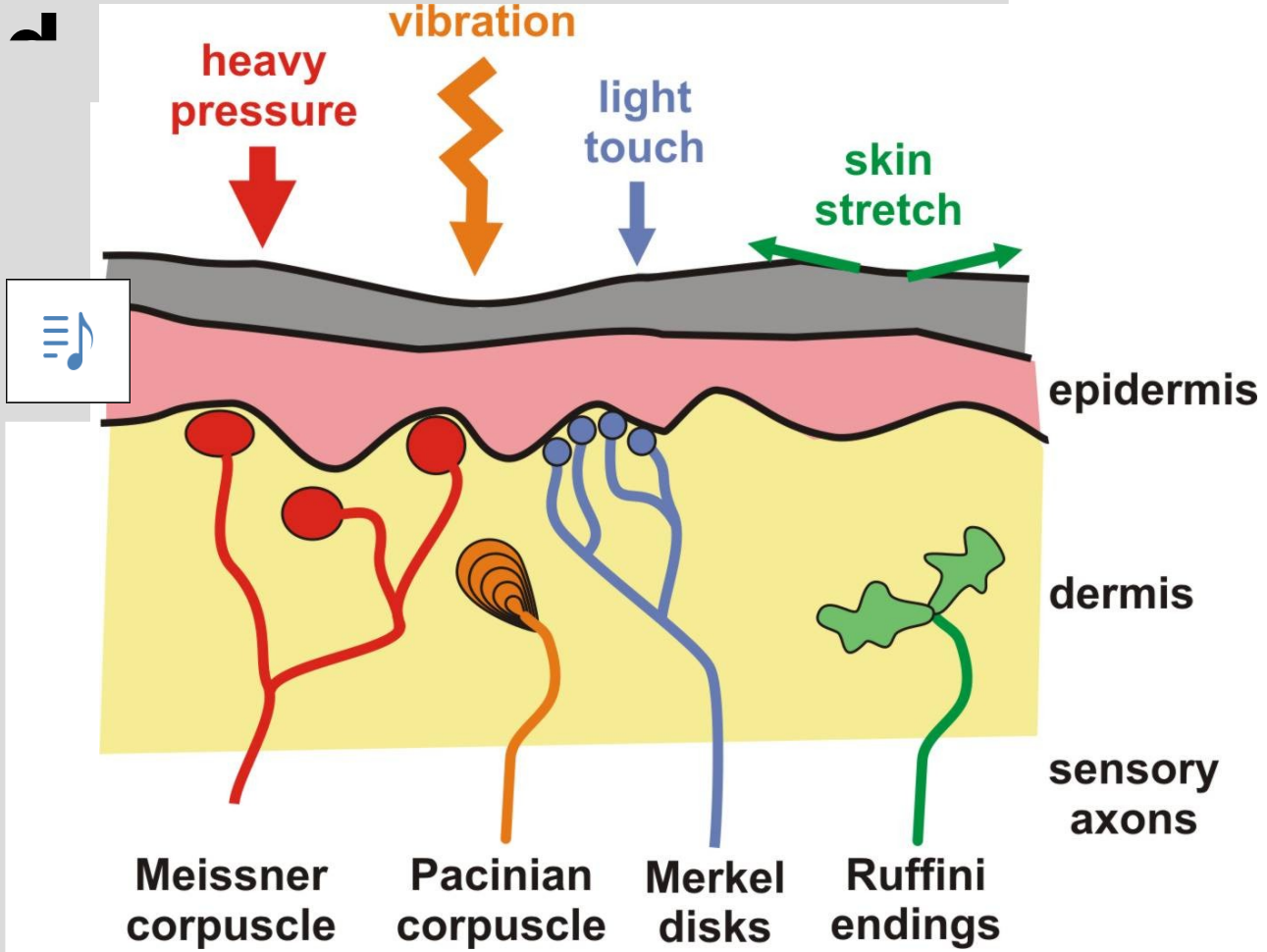
http://lpc1.clpccd.cc.ca.us/lpc/jgallagher/Physio/Chapter%206%20Homeostasis,%20Part%202.pdf

So, According to *the type of stimulus*, receptors can be classified

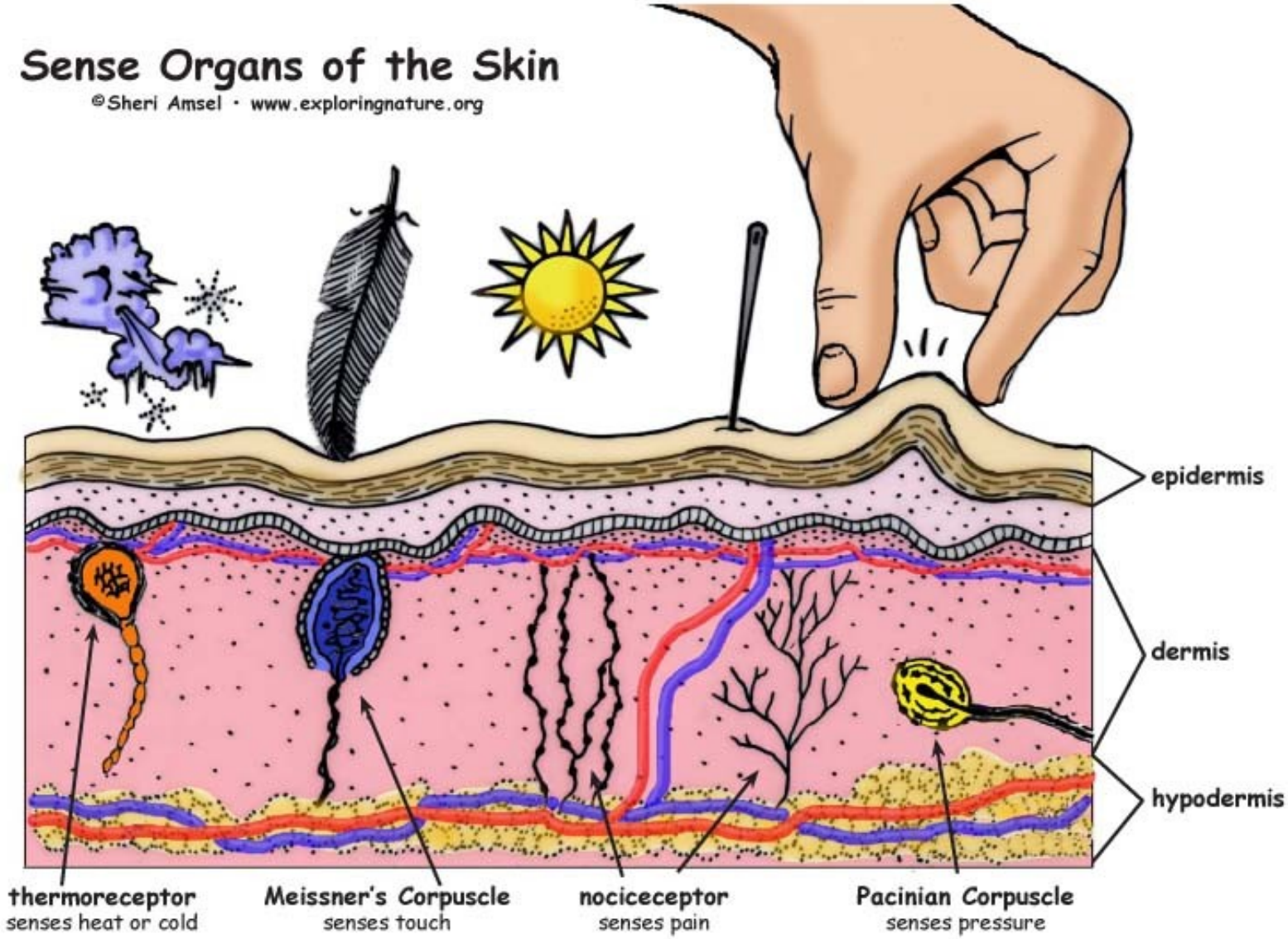
1) Mechanoreceptors:

Respond to mechanical stimuli and include:

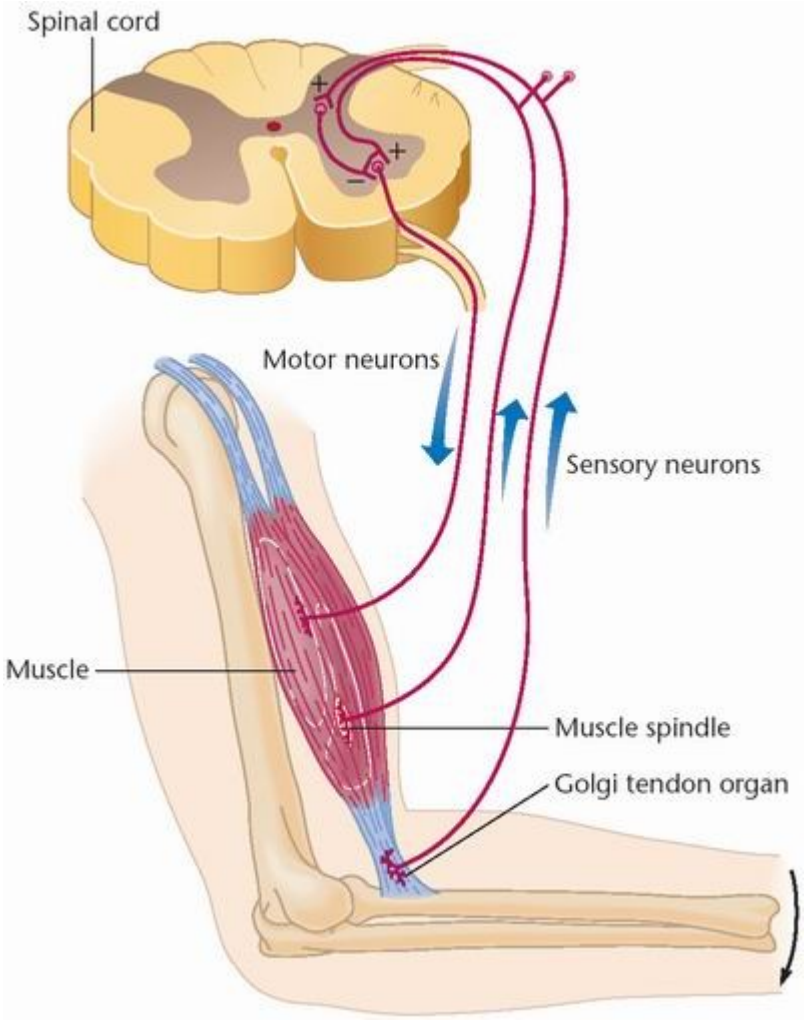
- **Touch, pressure and vibration receptors located in the skin.**



https://www.exploringnature.org/db/view/Touch



➢Proprioceptors located in muscles, tendons and joints.



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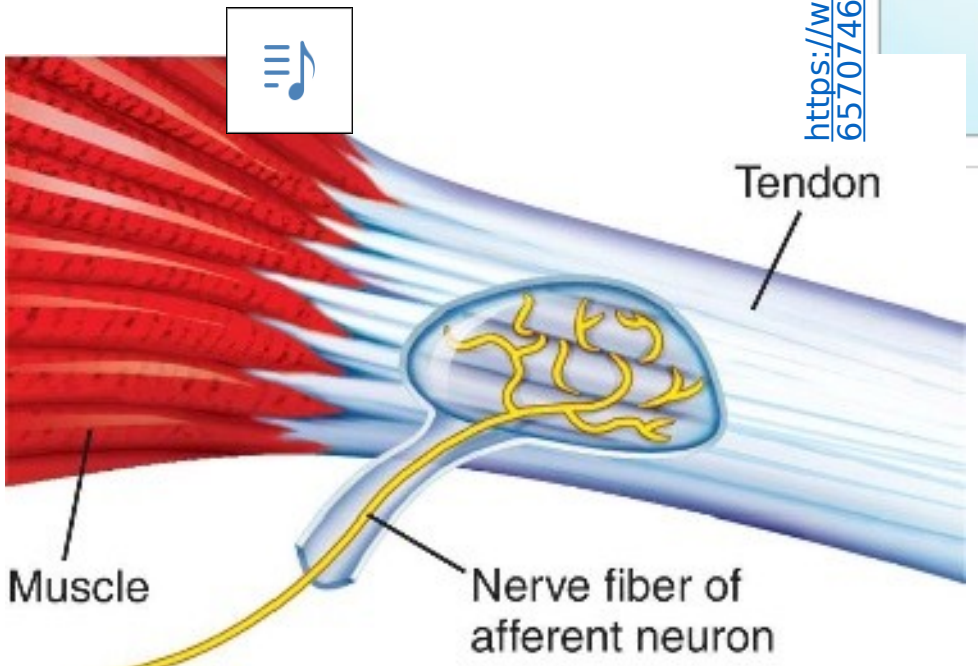

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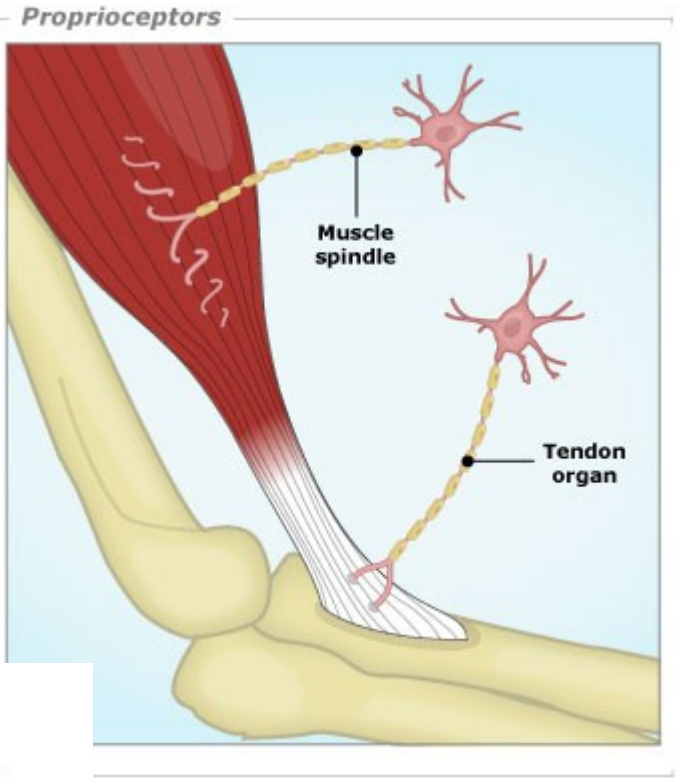

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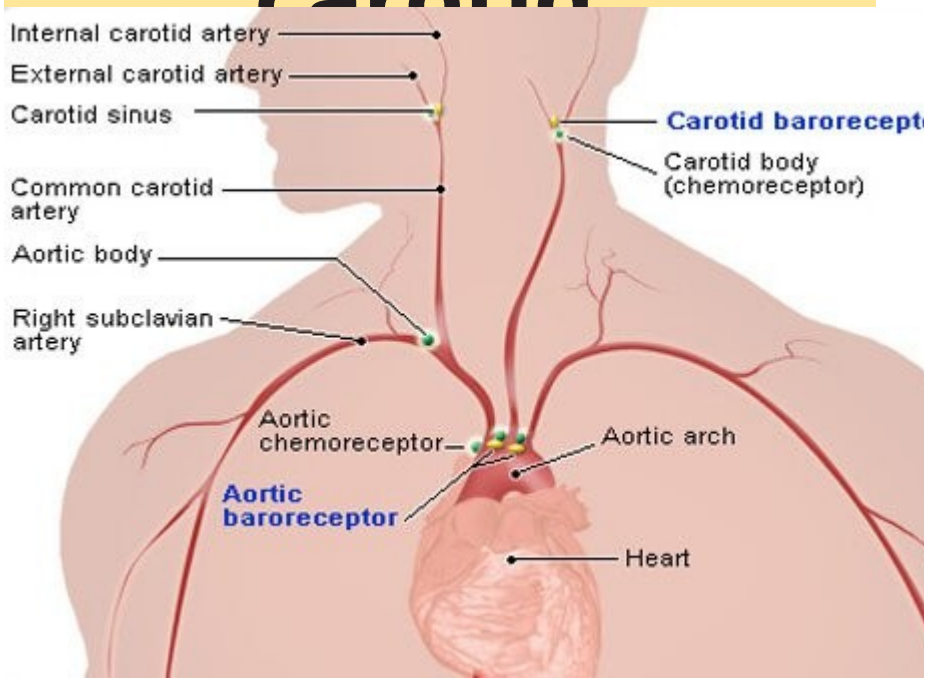
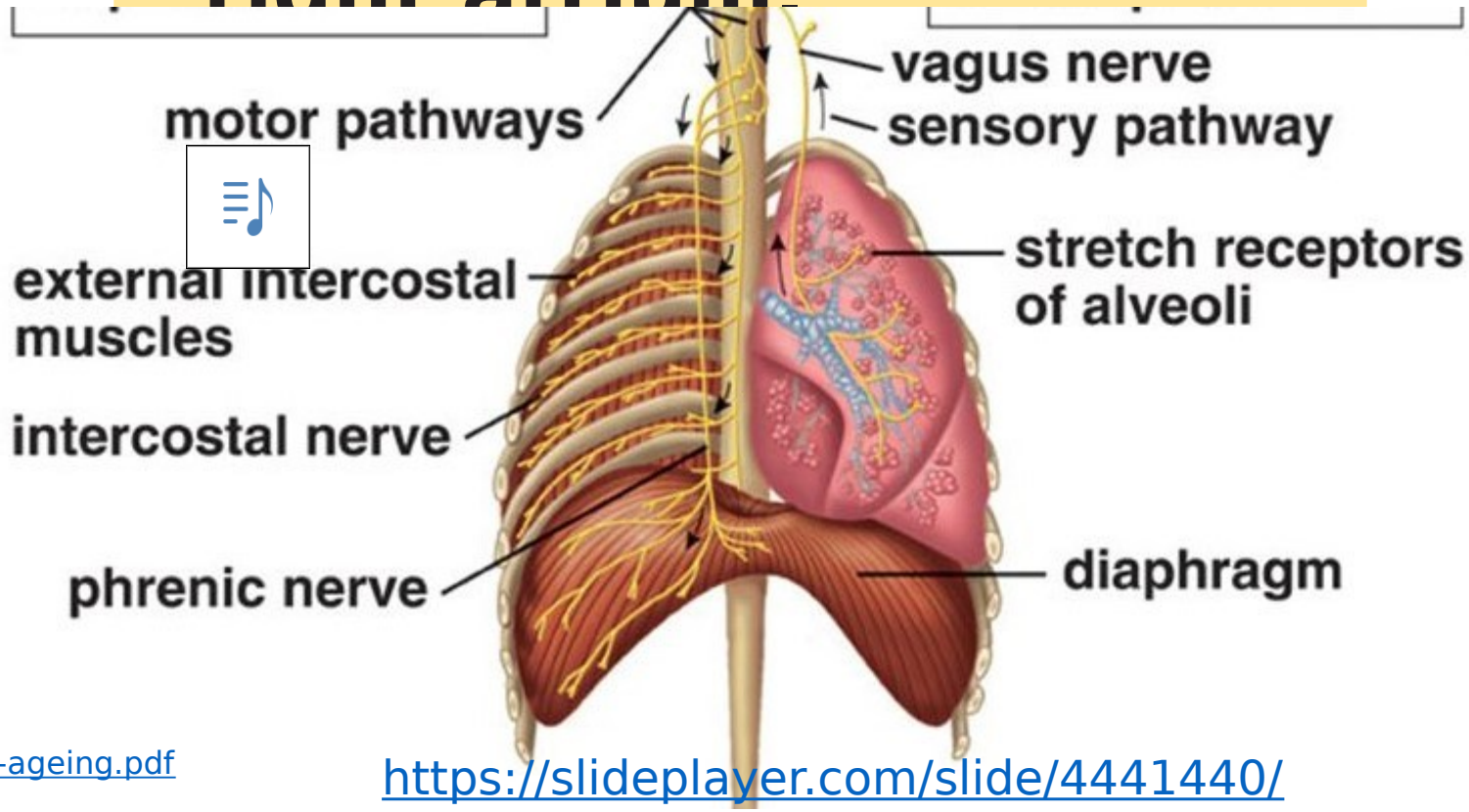
- **Barorecepto rs located in the aortic arch and carotid**



http://misa.ie/wp-content/uploads/2019/03/Vascular-brain-ageing.pdf

- **Stretch receptors located in the alveoli of the lungs and right atrium**



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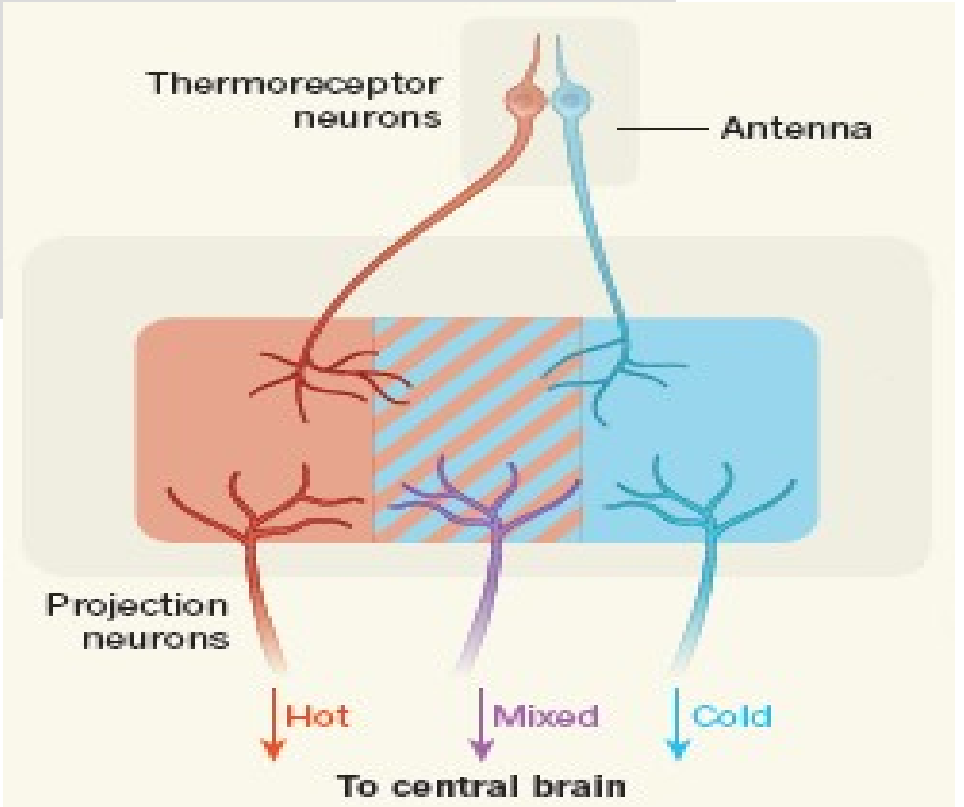
2)Thermoreceptors :

Stimulated by thermal form of energy and detect changes in temperature and include:

Cold receptors.

Warmth receptors.

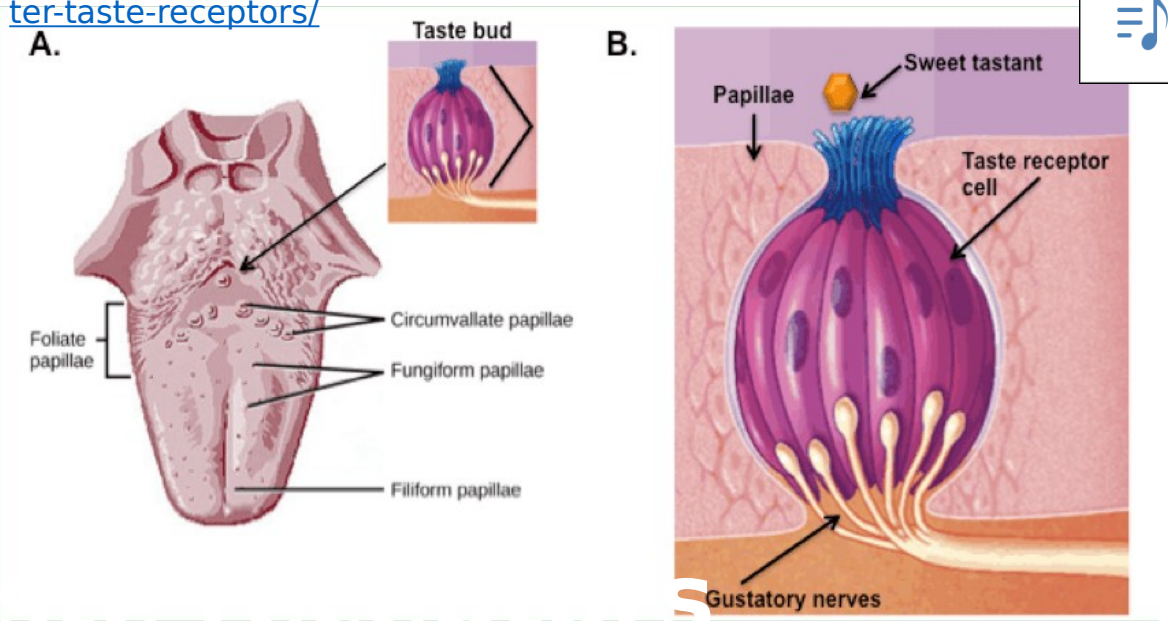


https://blogs.brandeis.edu/flyonthewall/breaking-research-how-the-brain-recognizes-hot-and-cold/

3) Chemoreceptors :

Stimulated by chemical forms of energy as taste, smell, and oxygen content in the blood;

http://sitn.hms.harvard.edu/flash/2013/the-bittersweet-truth-of-swe bitter-taste-receptors/



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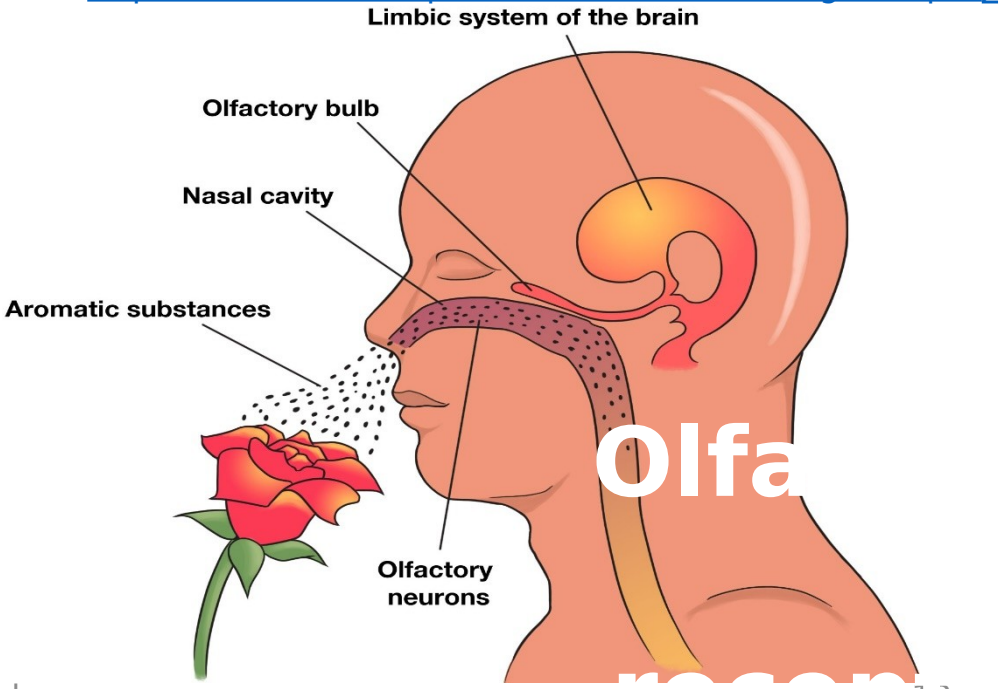
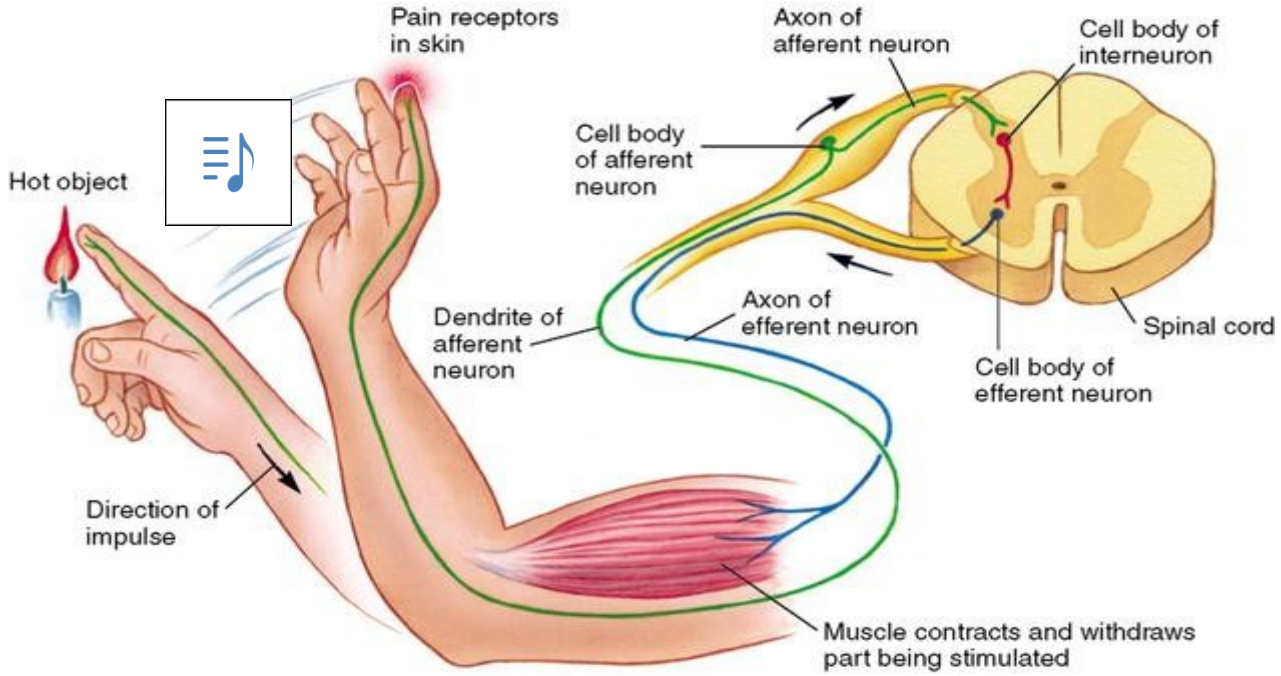


4) Nociceptors :

Stimulated by any form of energy potent enough to cause tissue damage.



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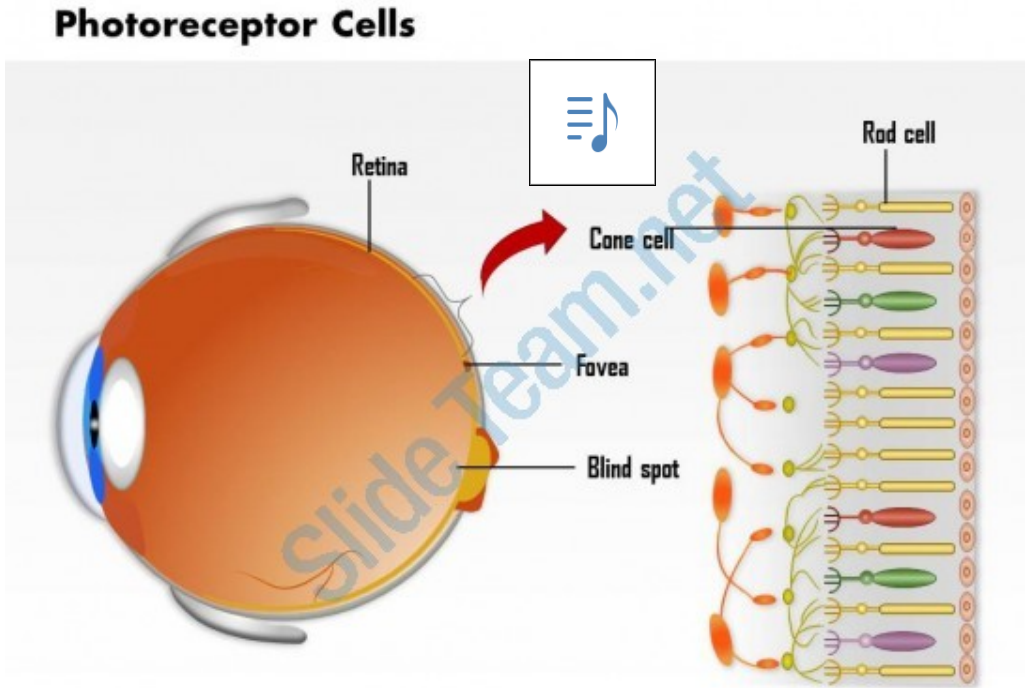
5) Electromagnetic receptors :

Respond to the electromagnetic waves of light. Include the rods and cones in the retina of the eye.



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Classify sensory receptors.

Properties of the sensory receptors

a. Differential sensitivity (specificity)

b. Excitability

c. Adaptation

a. Differential sensitivity (specificity)

Each receptor is most sensitive to one particular type of stimulus called its *adequate stimulus*.

The sensory fibre from the receptor terminates in an area of the brain that gives the sensation perceived by the receptor.

The sensation perceived as a result of stimulation of a receptor is called *modality of sensation*.

Differential sensitivity of receptors is illustrated by *Muller's law of specific nerve energies* which states that :

each receptor is most sensitive to one specific type of stimulus called its adequate stimulus giving rise to one type of sensation regardless of the method of stimulation because the sensation perceived depends on the area in the brain ultimately activated.

b. Excitability

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- **This is the ability of the receptor to respond to stimuli.**
- **At rest, the receptor is in the polarized state (with a resting membrane potential about -70 mV).**
- **However, if it is stimulated by *inadequate stimulus,* it is partially depolarized due to increased Na^+ influx secondary to Na^+ channel activation.**

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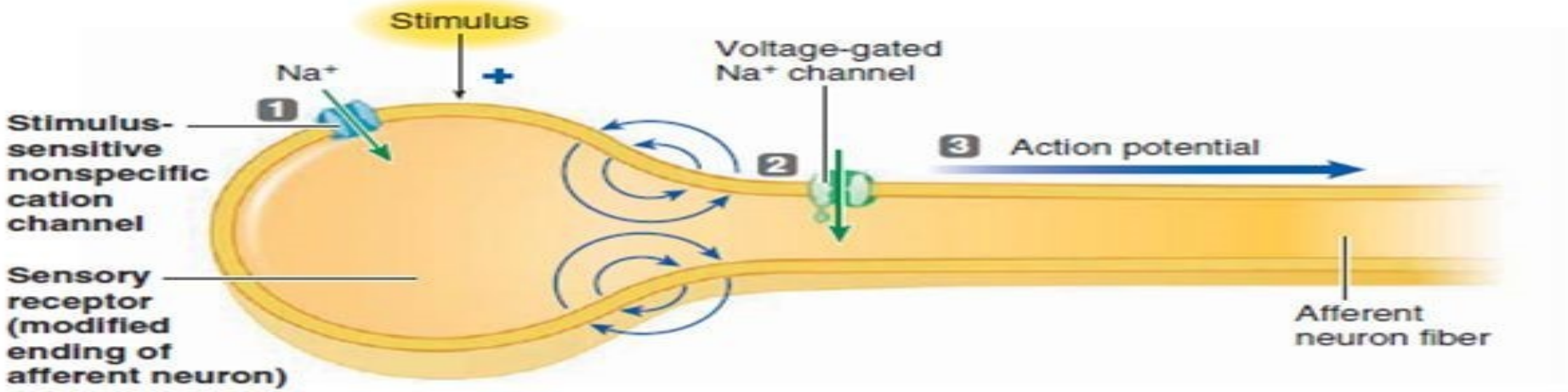
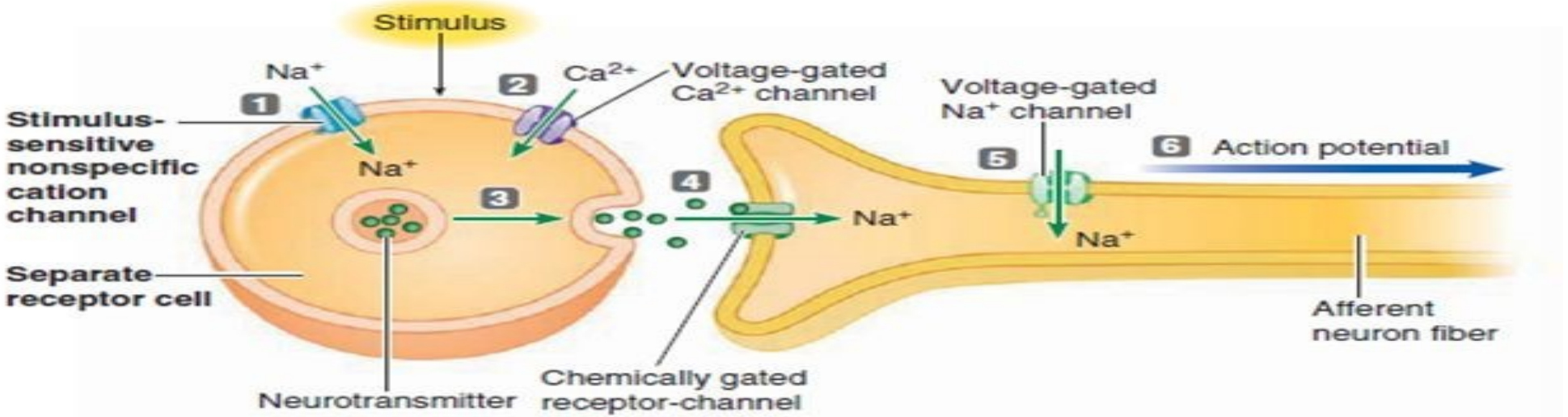


(a) Receptor potential in specialized afferent ending



(b) Receptor potential in separate receptor cell

➢**This state of partial depolarization of the sensory nerve ending is called the *receptor or generator potential*, and its magnitude is proportionate to the intensity of the stimulus (it increases with the increase of threshold of the stimulus).**

The receptor potential is passively conducted to the first node of Ranvier (by local circuits of current flow) causing its depolarization, and if this reaches the firing level (summation of the receptor potentials), it initiates an action potential that is propagated via the afferent nerve to the CNS.

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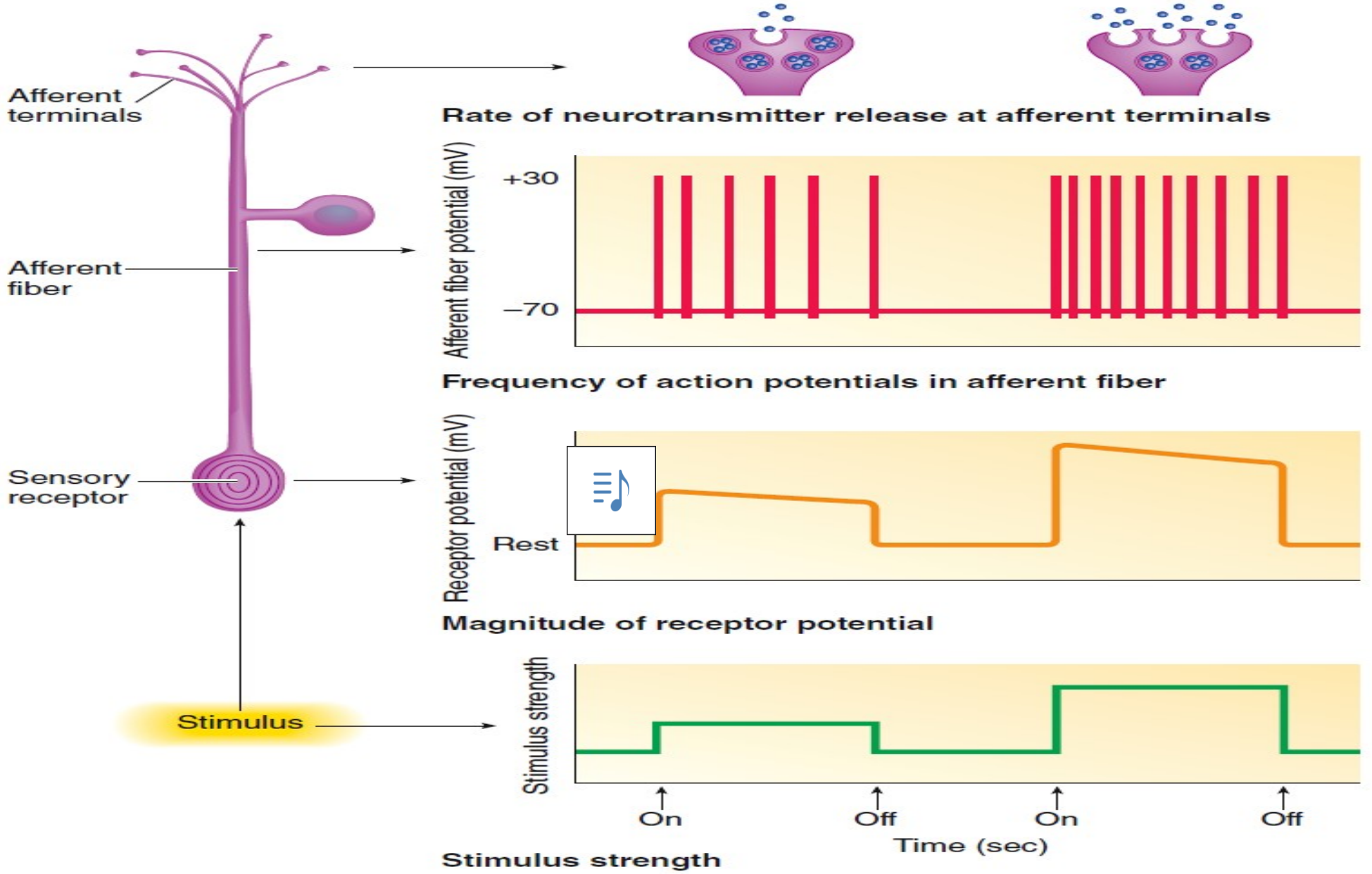

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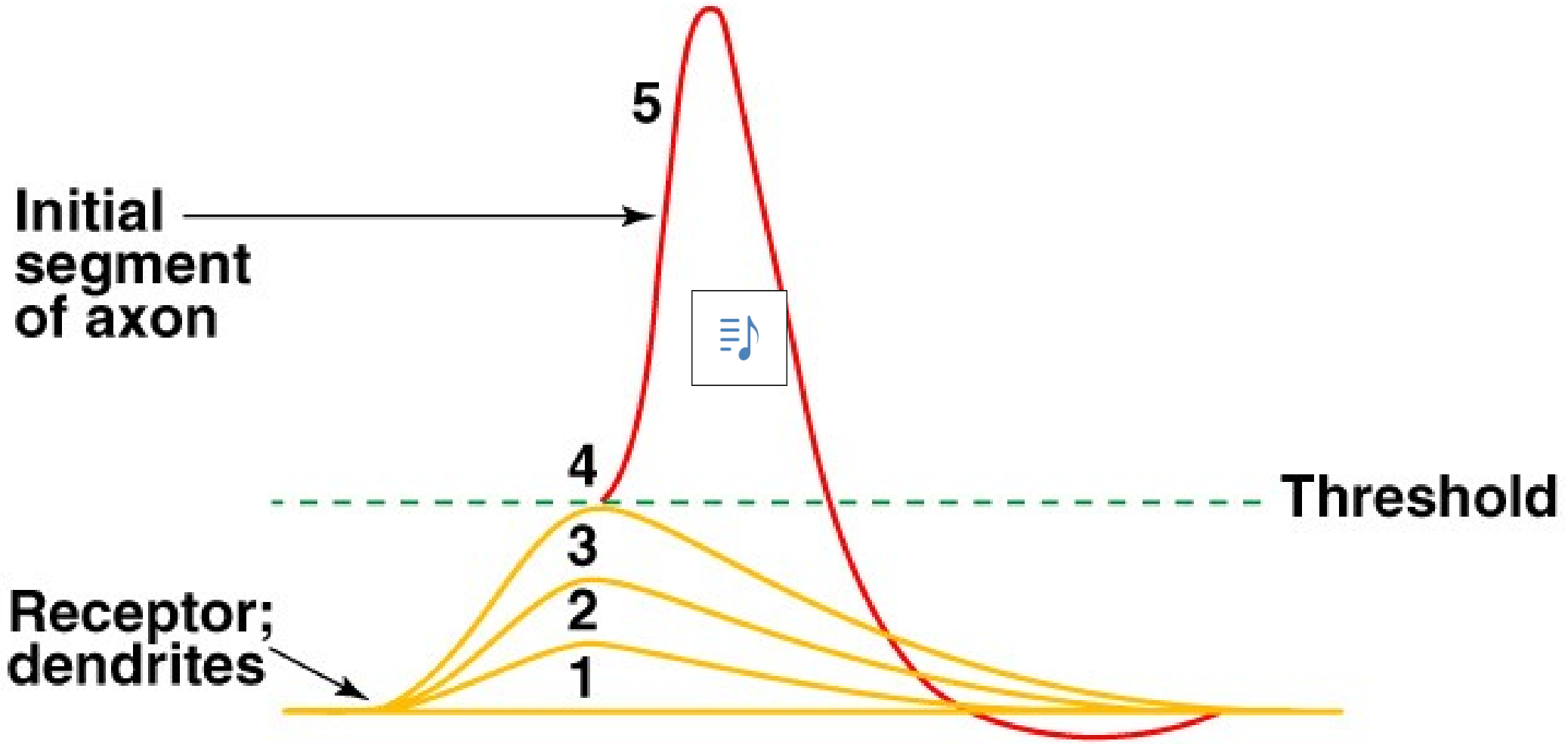
Generator Potentials



https://www.medicinebau.com/uploads/7/9/0/4/79048958/1a_sensory_system-slides.pdf

Properties of the receptor potential

It is a local, unpropagated potential whereas action potentials are propagated.

It is a graded potential i.e. it does not obey the all or none rule.

It has no refractory period, so it can be summated.

It is not blocked by local anaesthetics, whereas action potentials are blocked by these drugs.

c. Adaptation:

This is a decline in the frequency of discharge of action potentials from receptors that occurs on maintained stimulation by constant strength stimuli. Its degree varies with the type of receptor.

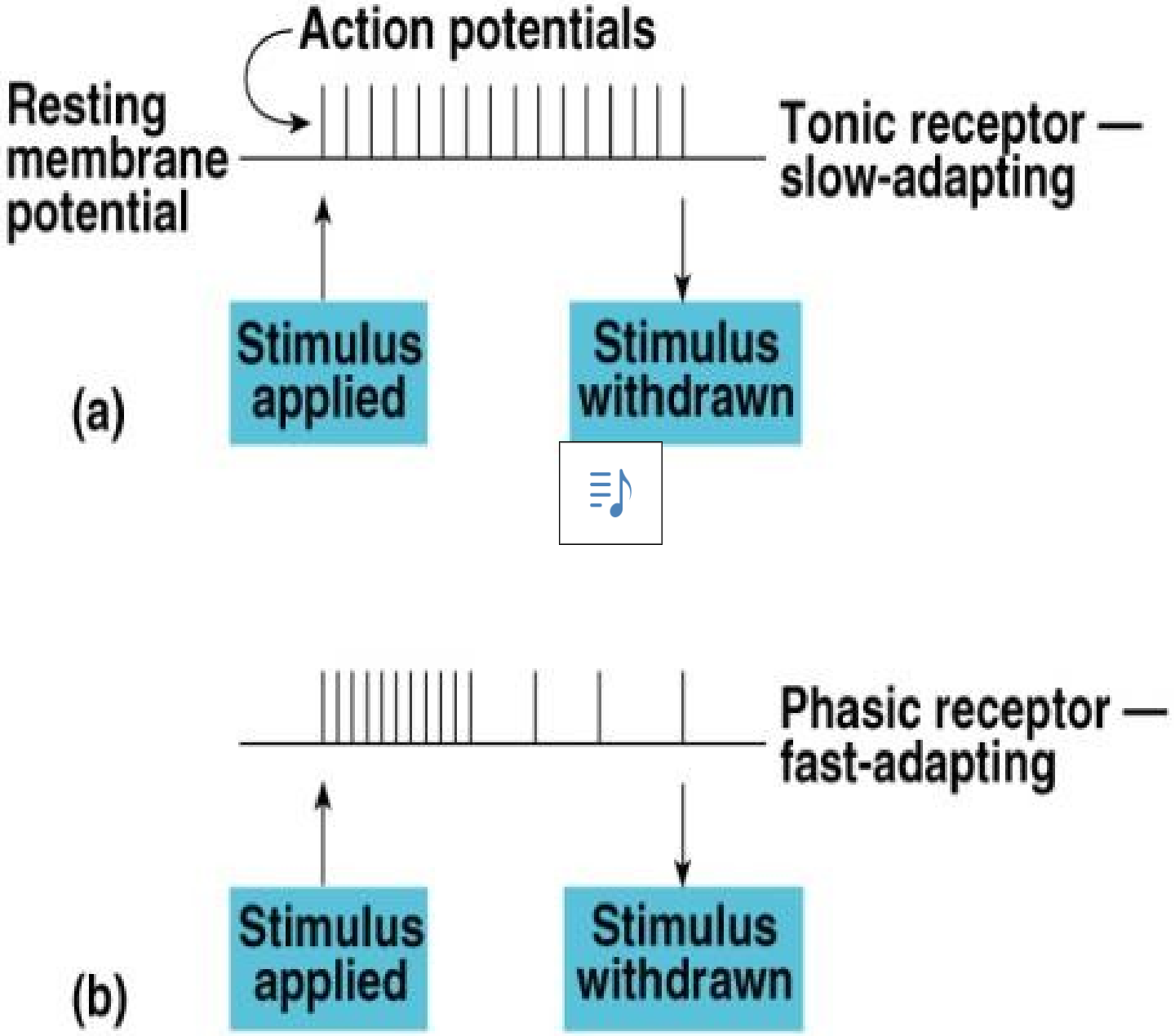
1. Rapidly adapting receptors (phasic receptors)

- In which the impulses declines rapidly in spite of maintained stimulation.
- Example: **touch receptors (particularly Meissner's and Pacinian corpuscles),** the rapid adaptation of which is important to avoid unnecessary and excessive sensations that might be irritating (e.g. there is no need to continuous information of the CNS about the presence of clothes).

2. Slowly adapting receptors (tonic re

❖These are called the tonic receptors because they continue discharging as long as they are stimulated.

❖ They include mainly the pain receptors & muscle spindles in which the slow adap tion is important because the continuous discharge of the pain receptors elicits protective reflexes that prevent tissue damage by noxious agents, while that of the muscle spindles allows the CNS to detect continuously the body posture & position of the limbs.



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Mechanisms of adaptation

1. Gradual closure of the Na+ channels (which decreases the magnitude of the receptor potential and, consequently the frequency of discharge).
2. Gradual decrease of the excitability of the first node of Ran r.
3. Loss of the stimulus energy in the surrounding tissues by constant stimulation.
4. Accommodation of the afferent nerve fibre to the generator potential (receptor potential).

numerate properties of receptor

Coding of sensory information :

It is the ability of the nervous system to discriminate (or identify) the modality, locality and intensity of the various sensations, although all types of sensations are transmitted from their receptors to the higher centers via specific sensory pathways in the same form (i.e. as action potentials).

Modality discrimination (Specificity)

Discrimination of the modality of a sensation by the brain depends on the [illegible]equate stimulus to which the receptor is specialized and on the area of the brain ultimately activated.

b. Locality discrimination (projection):

- It depends on the fact that each receptor has a specific pathway to the sensory cortex where different parts of the body are represented.
- Stimulation of a sensory pathway anywhere along its course to the sensory cortex produces sensation referred to the location of the receptor.

- This effect is called "law of projection", and it is clear in patients whose limbs are amputated for any reason, who may feel severe pain in the phantom limb (non-existing limb) due to irritation of the sensory nerves at t
amputation.

c. Intensity discrimination

- The discrimination of the sensation intensity depends on the following

a.The number of activated receptors: This increases as the stimulus intensity is increased (recruitment of receptors).

b.The discharge frequency from the activated receptors: A high discharge frequency is interpreted by the higher centres as an increased intensity of the sensation.

c.The state of nerve centres: In cases of CNS depression e.g. as a result of severe oxygen lack or

What is the relation between the frequency of discharge in a sensory receptor & the intensity of sensation?

Lecture Quiz

1. **Which of the following is considered phasic receptors ?**
   - a. Golgi tendon organs.
   - b. Free nerve endings.
   - c. Baroreceptors in the carotid sinus.
   - d. Pacinian corpuscles .
   - e. Warmth receptors.

2. **Which is the correct answer regarding sensory receptors ?**
   - a. Stimulus energy is converted into a local depolarization.
   - b. The generator potential is graded and self-propagating.
   - c. A generator potential can be produced by only one form of energy.
   - d. The frequency of action potentials generated doubles when the strength of the stimulus doubles.
   - e. Serving touch sensation, constant supra-threshold stimulation causes action potentials to be generated at a constant rate.

Summary

- **Sensory receptors: Modified nerve endings of afferent fibers that receive & convert stimuli into action potentials.**

.Receptors are classified according to the type of the stimulus into: mechanoreceptors, thermo-receptors, chemoreceptors, nociceptors & electromagnetic receptors.

.Properties of sensory receptors: specificity, excitability & adaptation.

- **Receptor potential is a state of partial depolarization in the receptor membrane occurs when the receptor is stimulated.**

.Frequency of action potentials reaching the brain determine the strenght of sensation.

.Receptor adaptation is decline in receptor potential & frequency of impulses despite constant maintaine application of the stimulus.

.Coding for sensory information is the ability of nervous system to recognize type, site & strength of sensation.

SUGGESTED TEXTBOOKS

1. **Guyton and Hall Textbook of Medical Physiology.**
   https://www.amazon.com/Guyton-Hall-Textbook-Medical-Physiology/dp/1455770051

2. **Ganong's Review of Medical Physiology, 25e.**

   https://www.amazon.com/Ganongs-Review-Medical-Physiology-Twenty-Fifth/dp/007182510X

3. **USLME step 1 lecture notes physiology 2017.**
   https://drive.google.com/drive/folders/1b6hSiwAzGyRypOTDCnnBw68MmQEVRv-u?usp=sharing


Thank You